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(54) APPARATUS USED TO PACKAGE MULTIMEDIA CARD BY TRANSFER MOLDING

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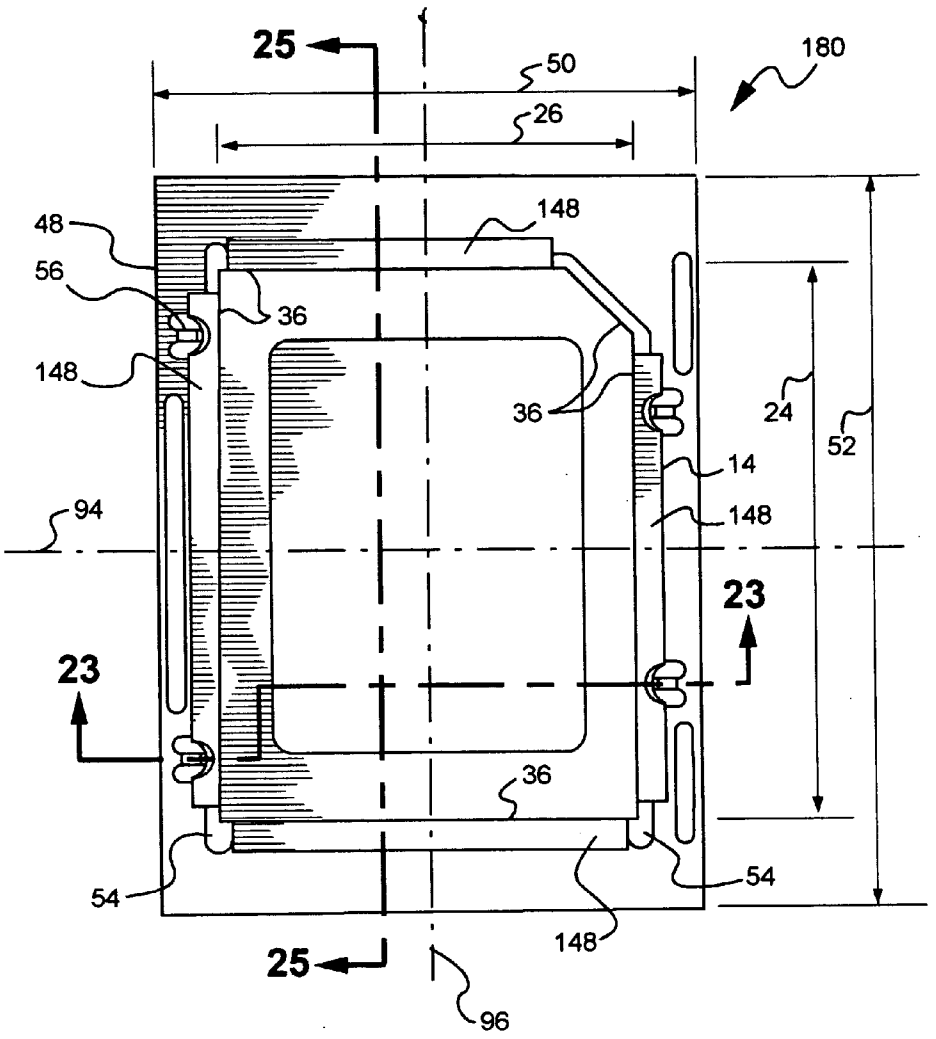
(57) ABSTRACT

A semiconductor card is made by an apparatus using a method which in one molding step forms a plastic body on a substrate attached to a surrounding frame by narrow connecting segments spanning a peripheral opening. The connecting segments are motivated downward by pins outside of the card periphery, holding the substrate against a lower level of the mold cavity during molding. Molded wings extending laterally from the card periphery are also formed. Following molding and curing, the casting is removed and the card singulated by excising the wings from the card. The resulting card has smooth edge surfaces and precise dimensions. Separate glob top encapsulation is avoided.



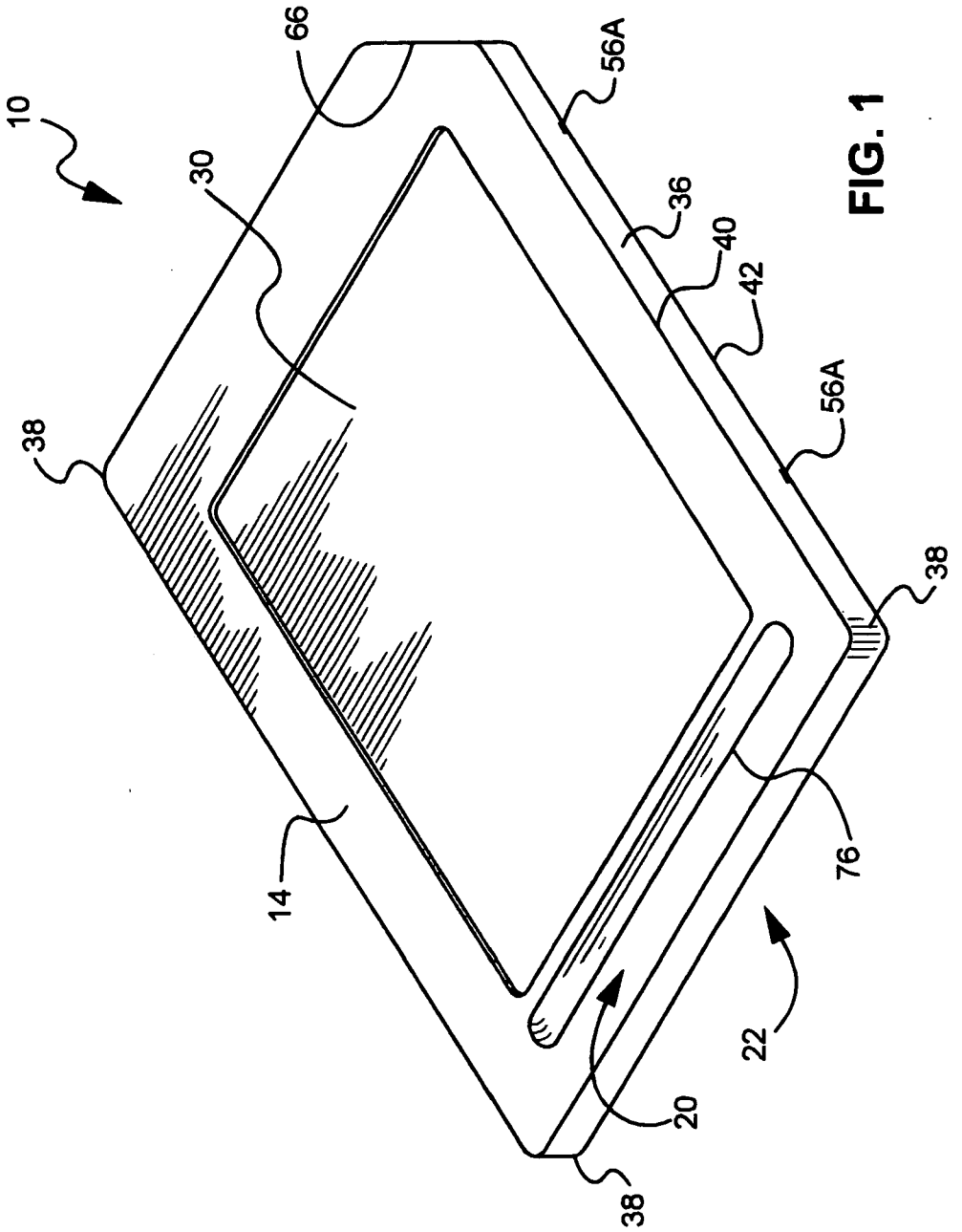



FIG. 1

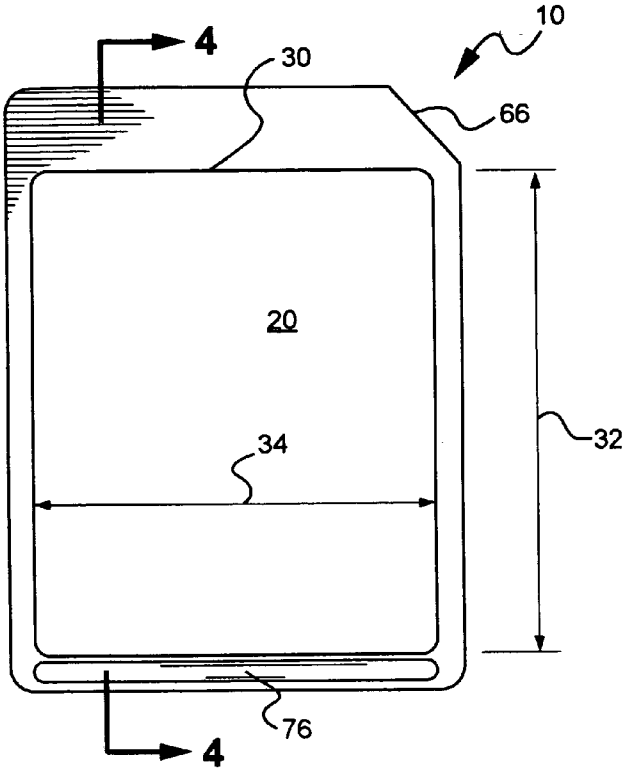



FIG. 2

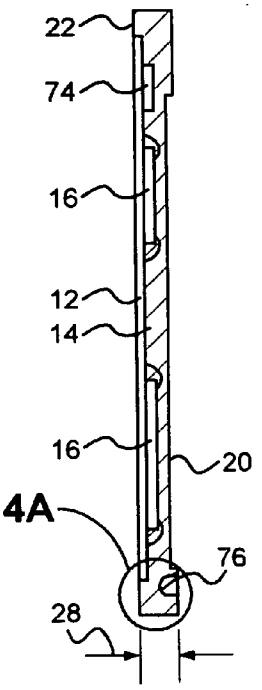



FIG. 4

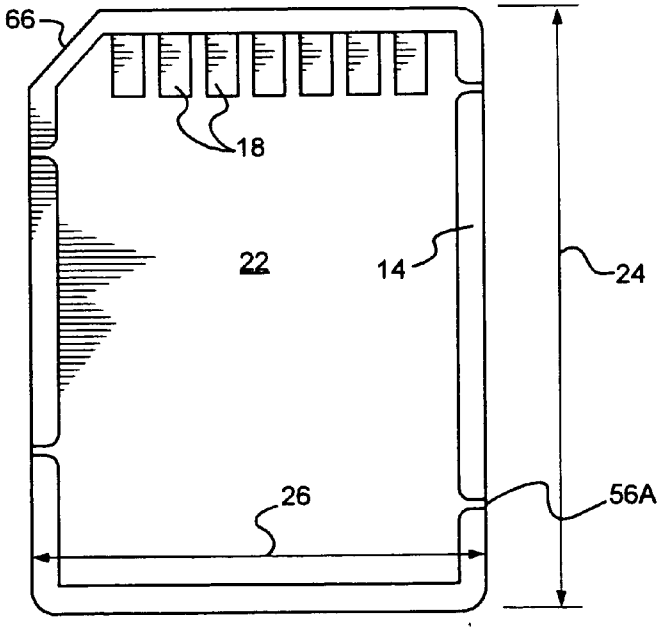



FIG. 3

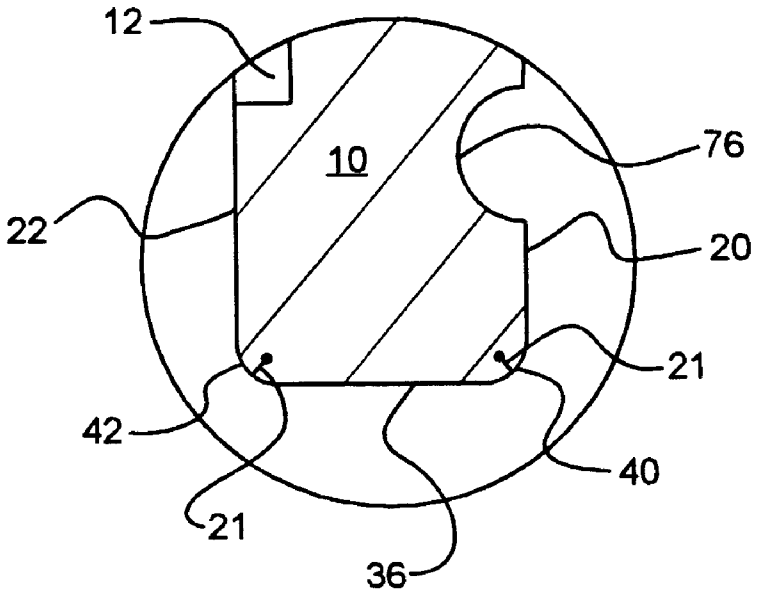



FIG. 4A

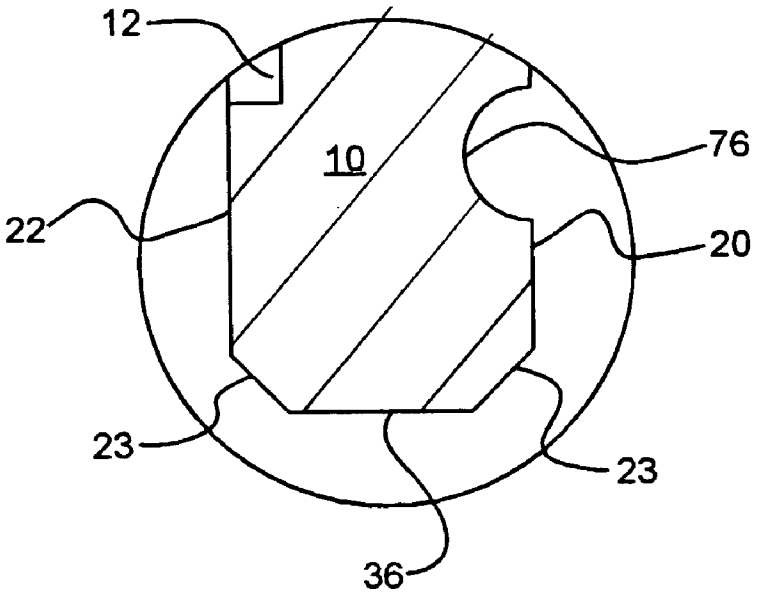



FIG. 4B

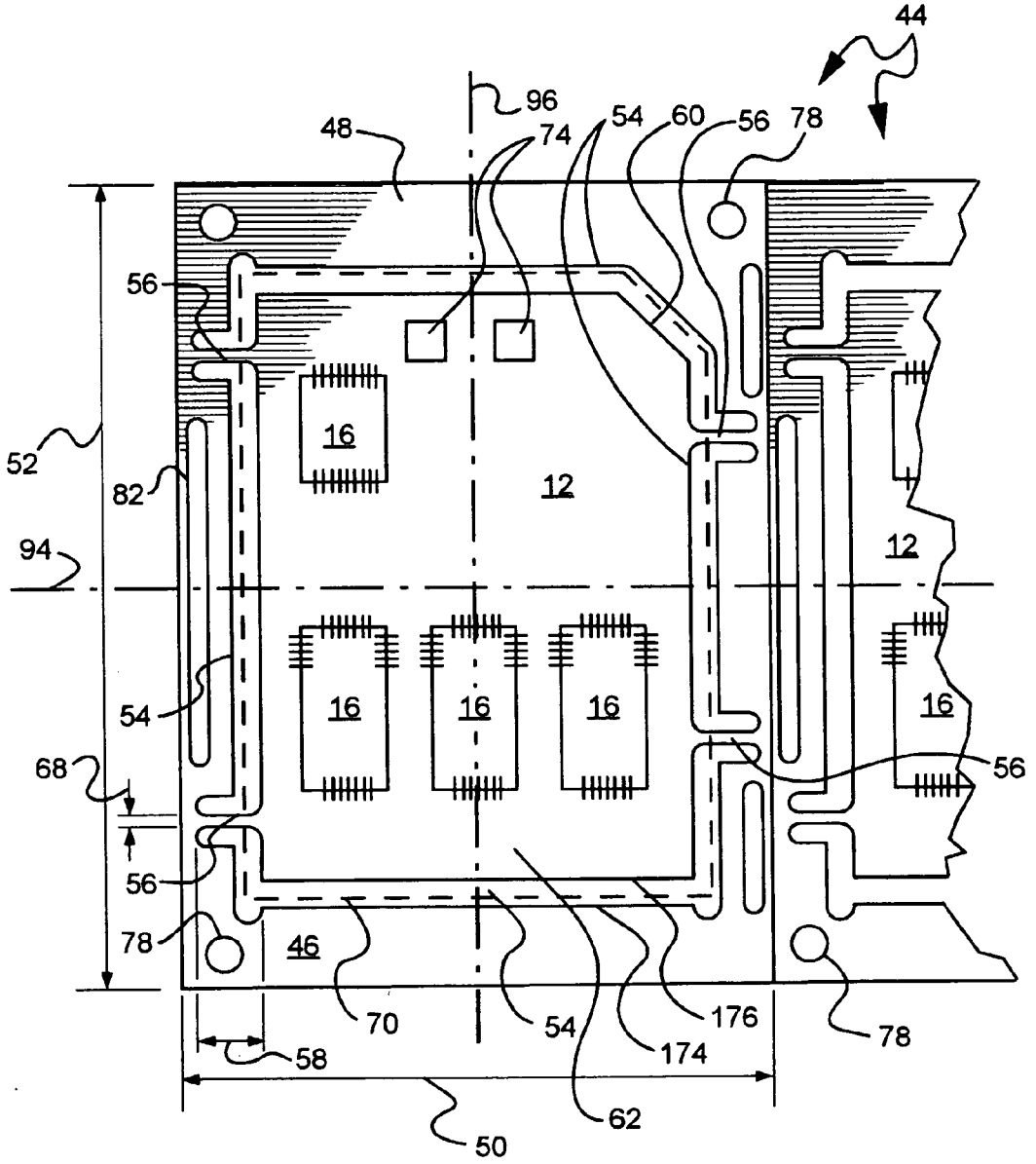

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FIG. 5

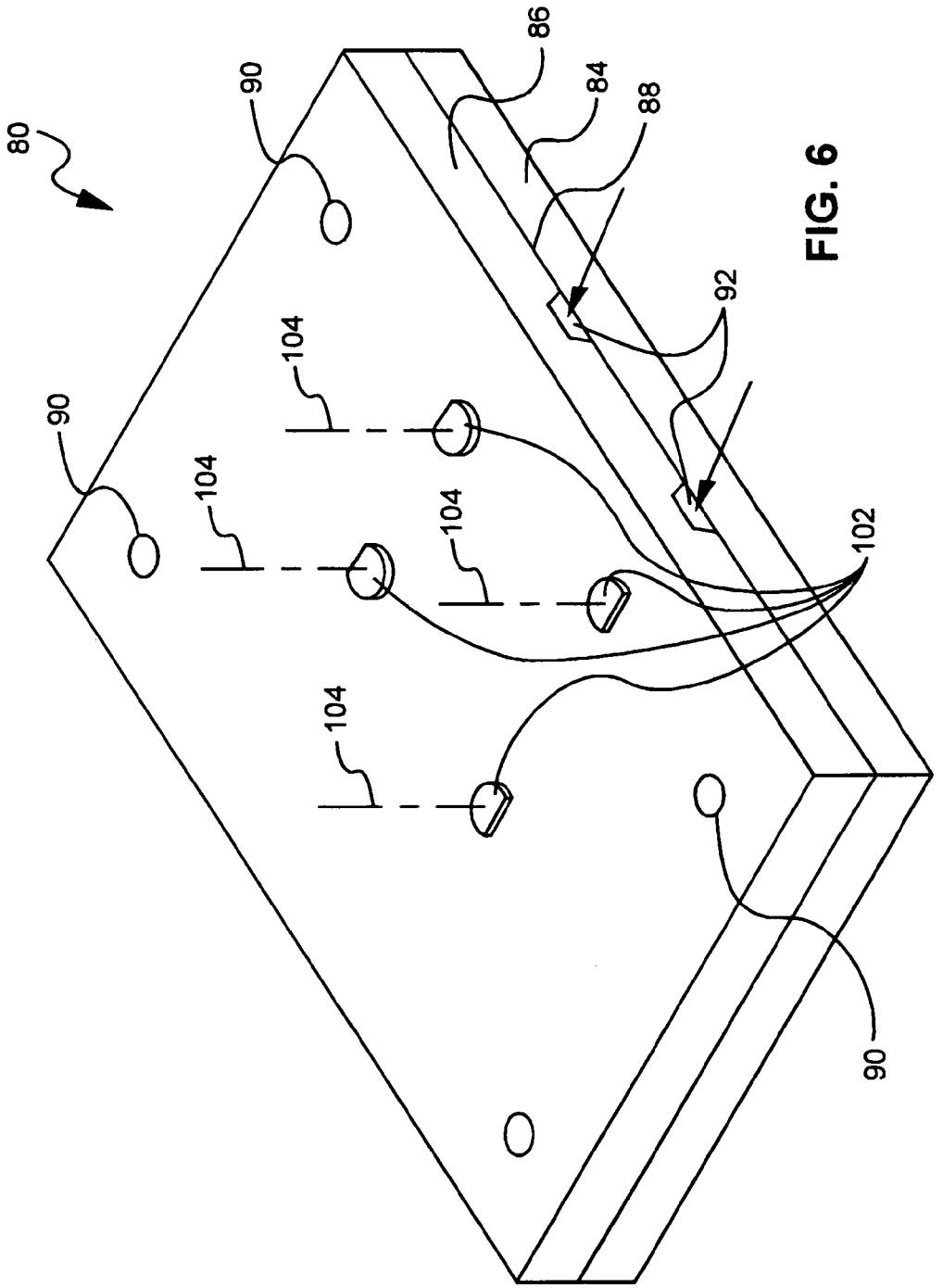


FIG. 6

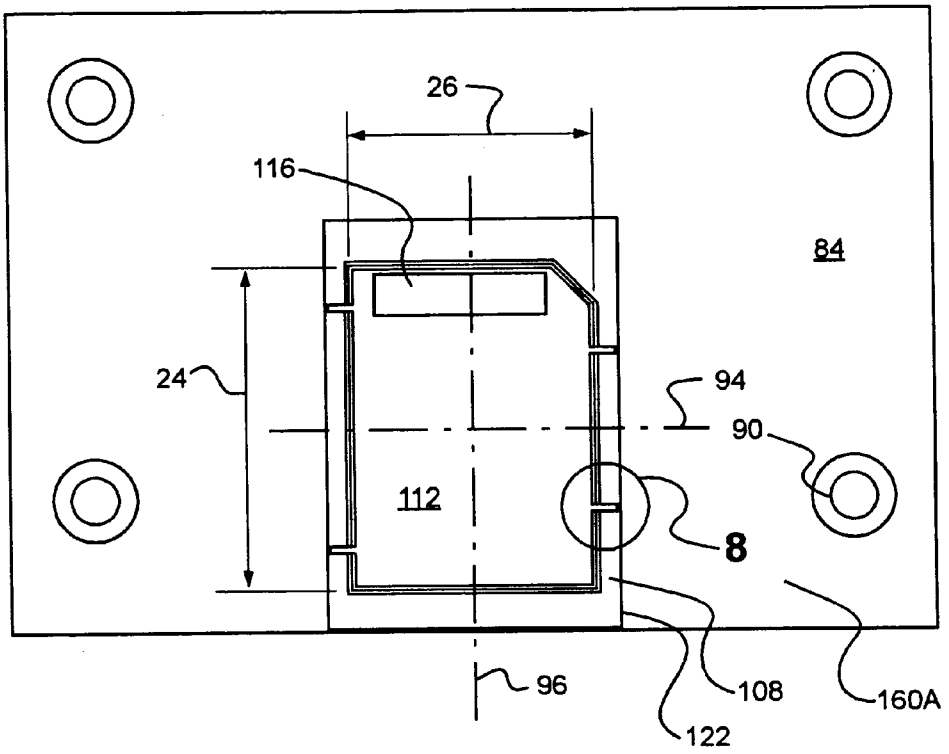


FIG. 7

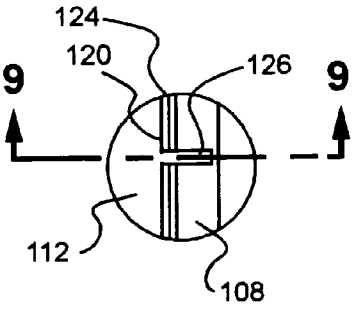


FIG. 8

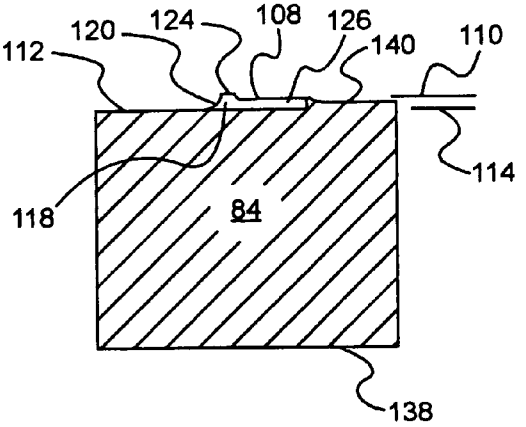


FIG. 9

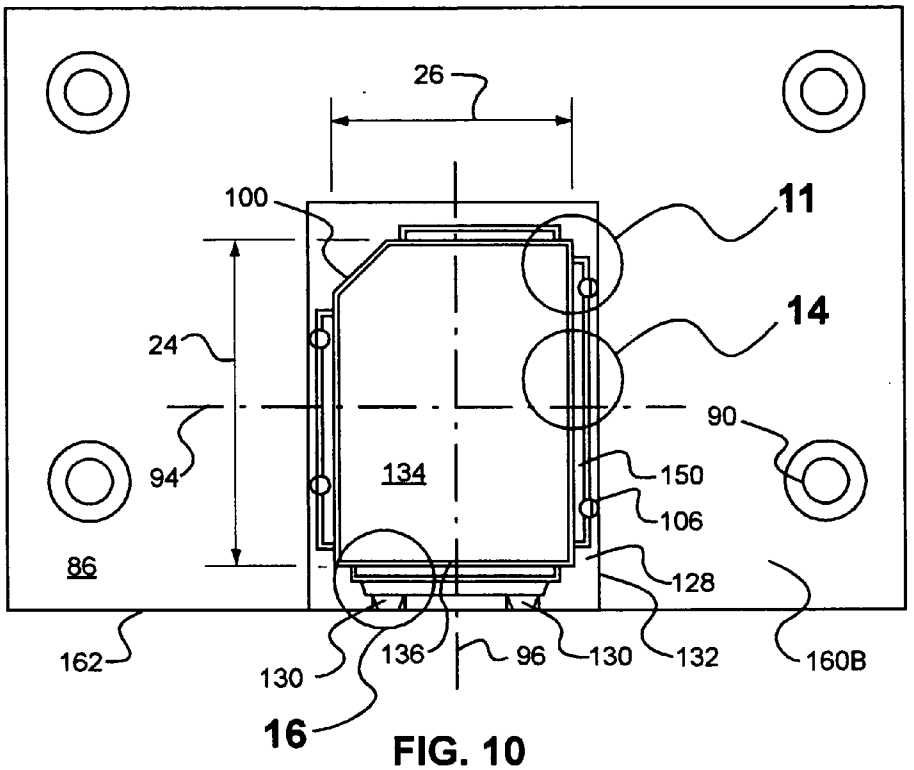


FIG. 10

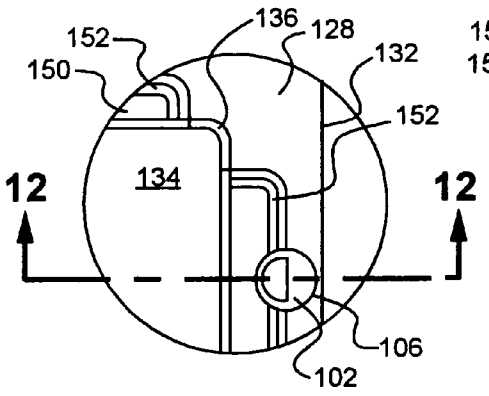


FIG. 11

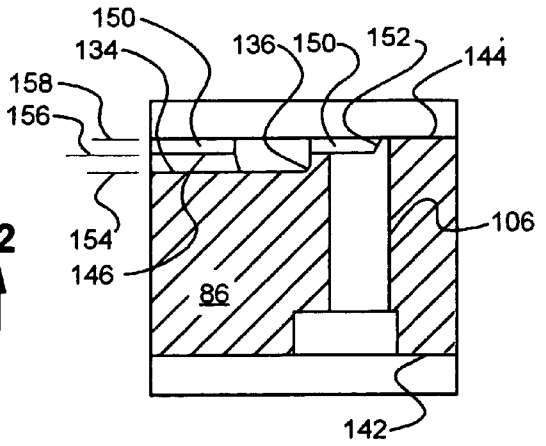


FIG. 12

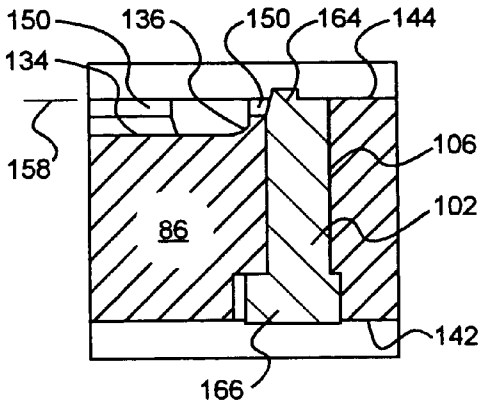


FIG. 13

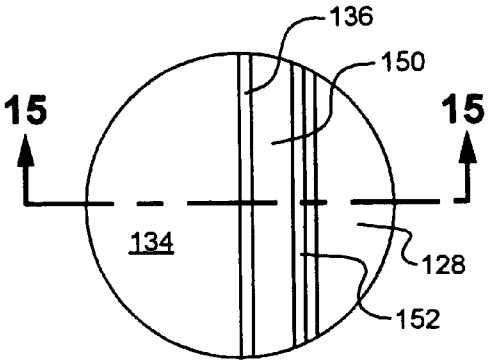


FIG. 14

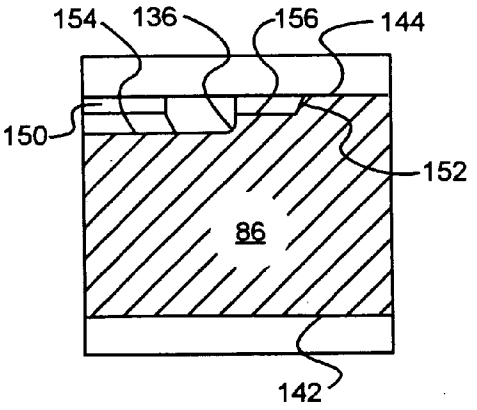


FIG. 15

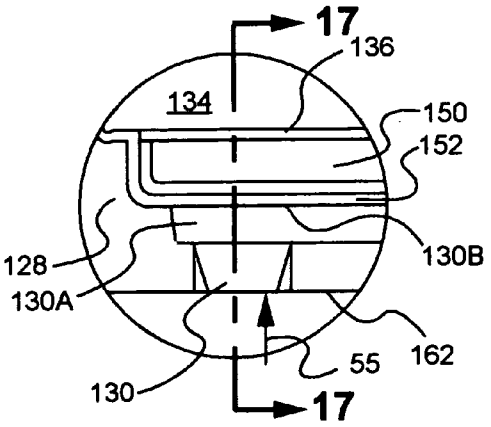


FIG. 16

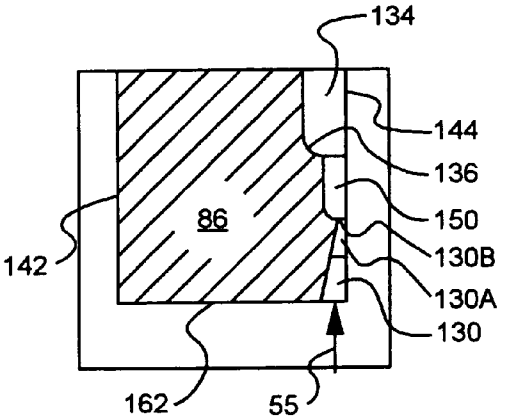


FIG. 17

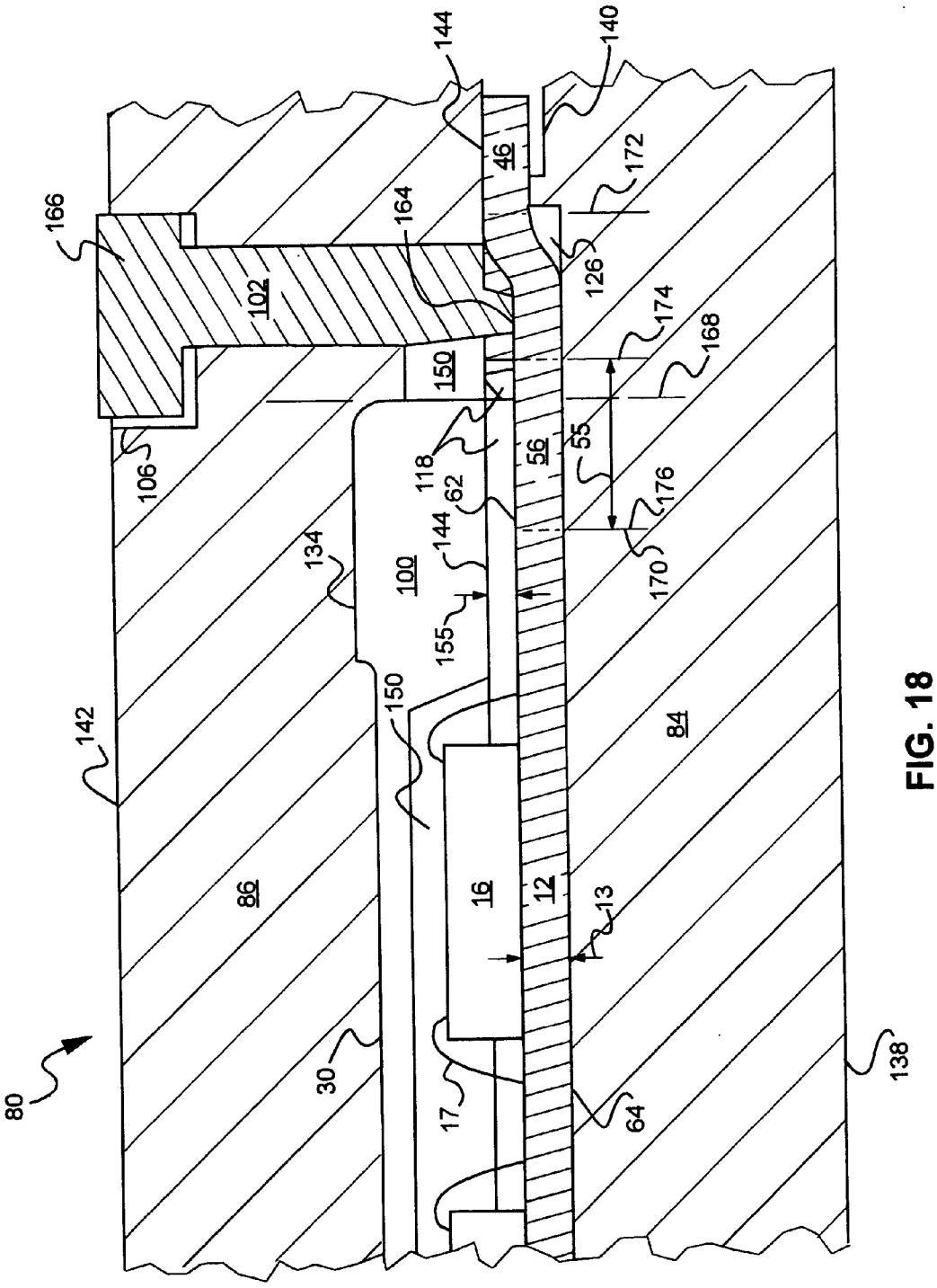
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FIG. 18

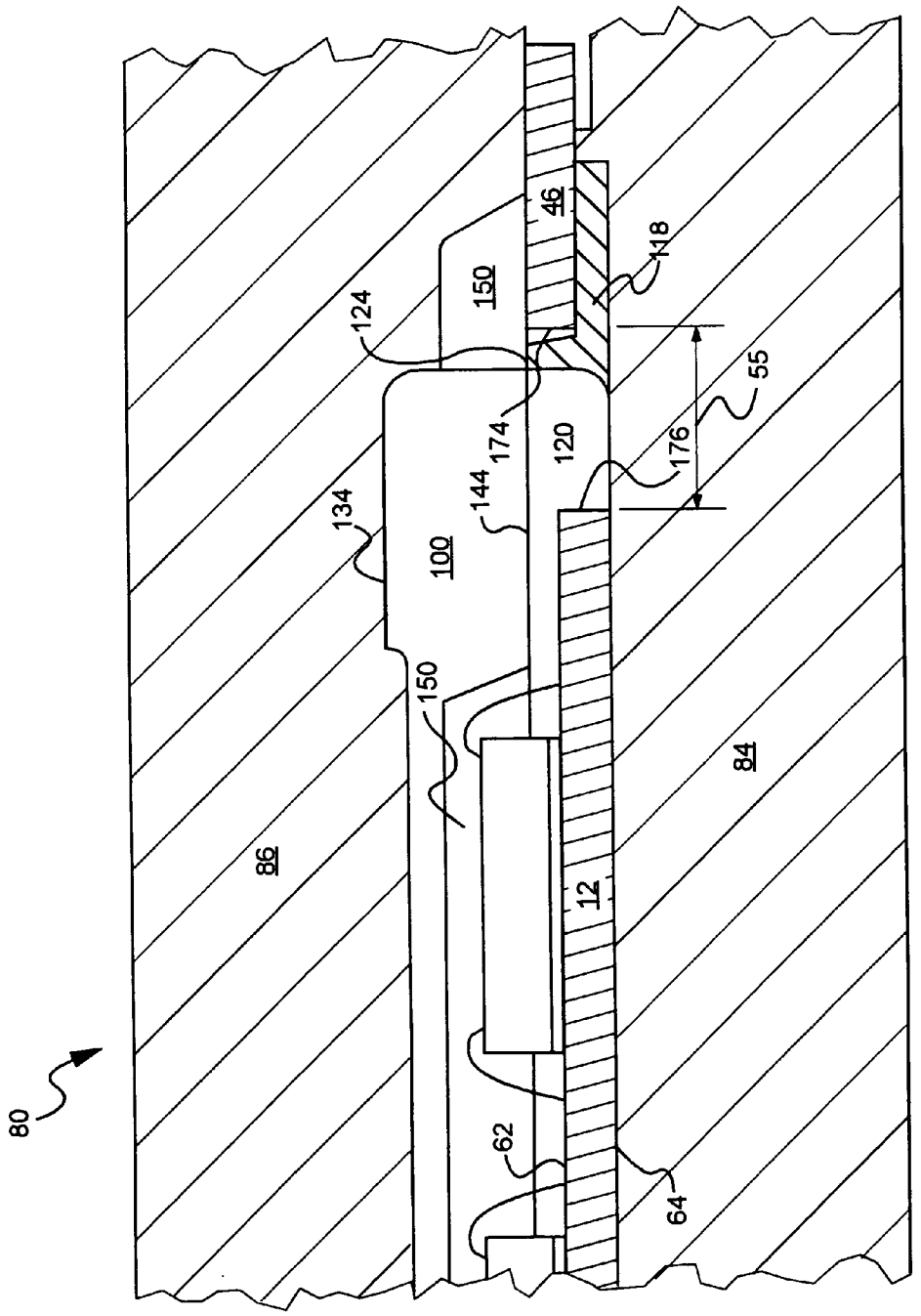


FIG. 19

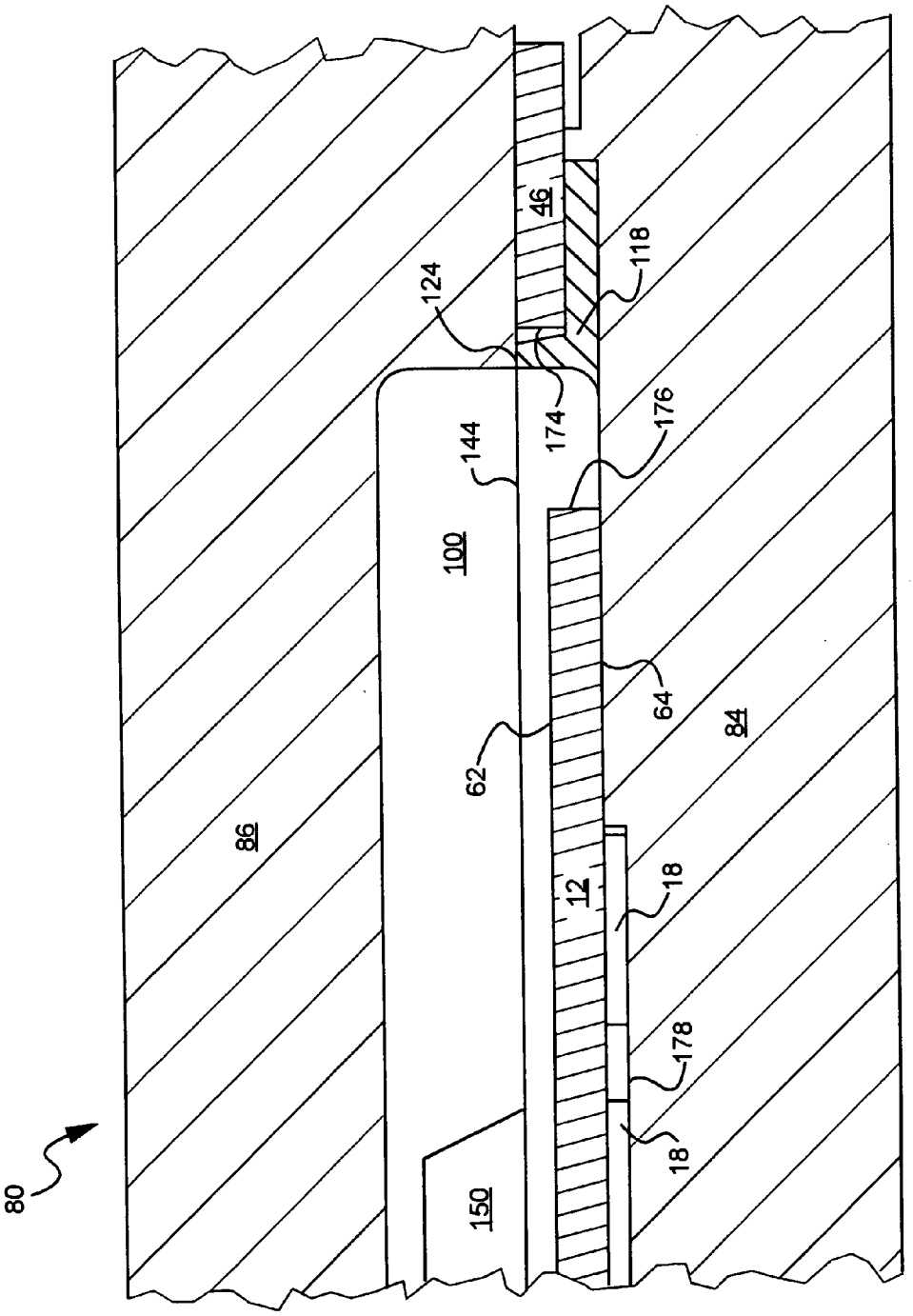


FIG. 20

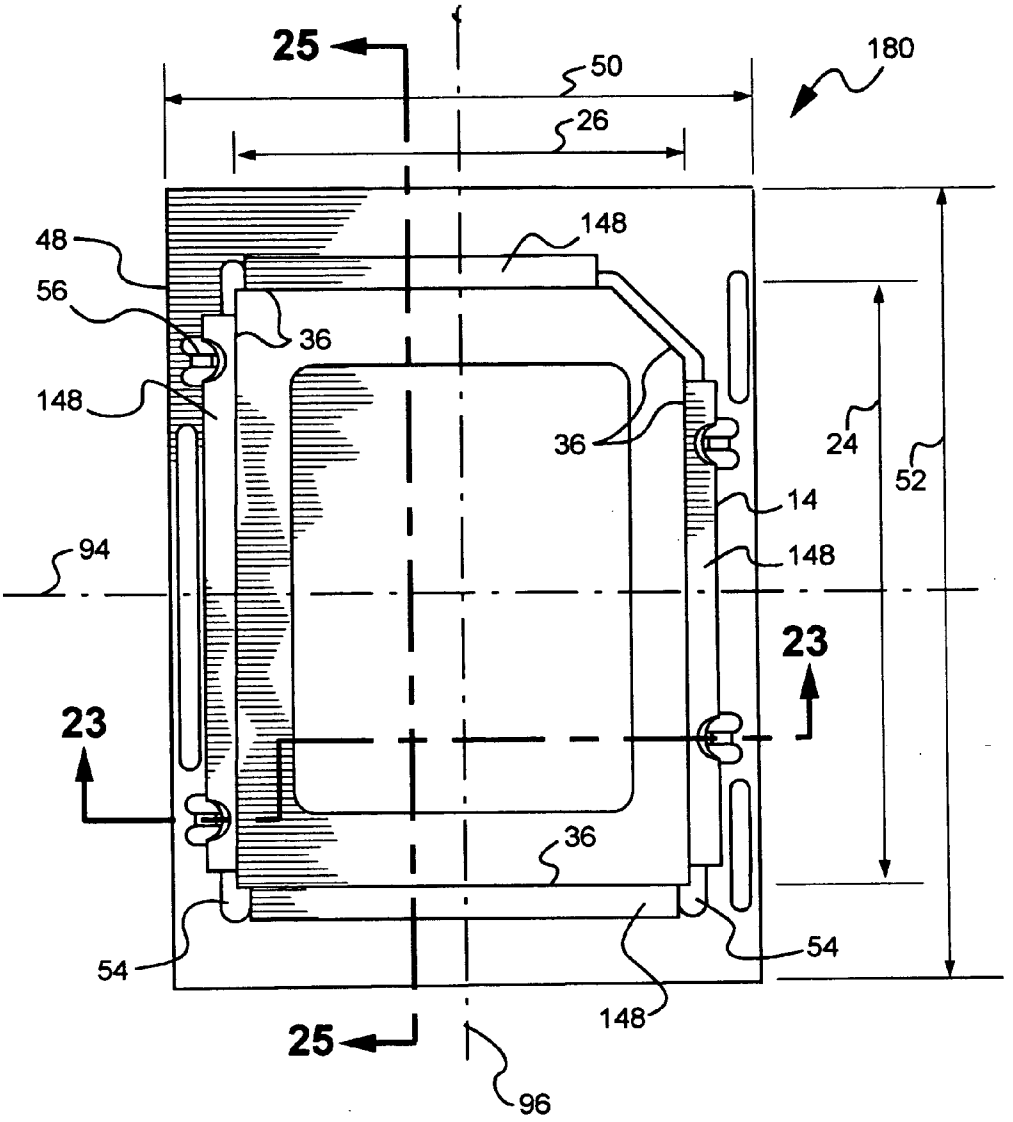
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FIG. 21

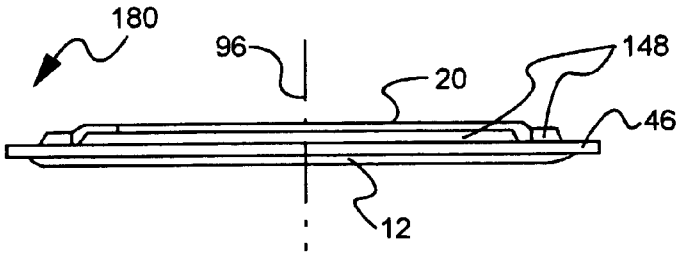
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FIG. 22

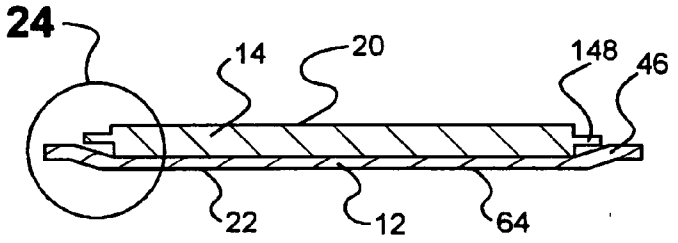


FIG. 23

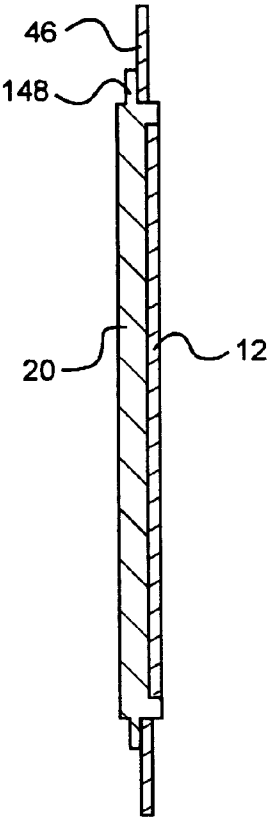


FIG. 25

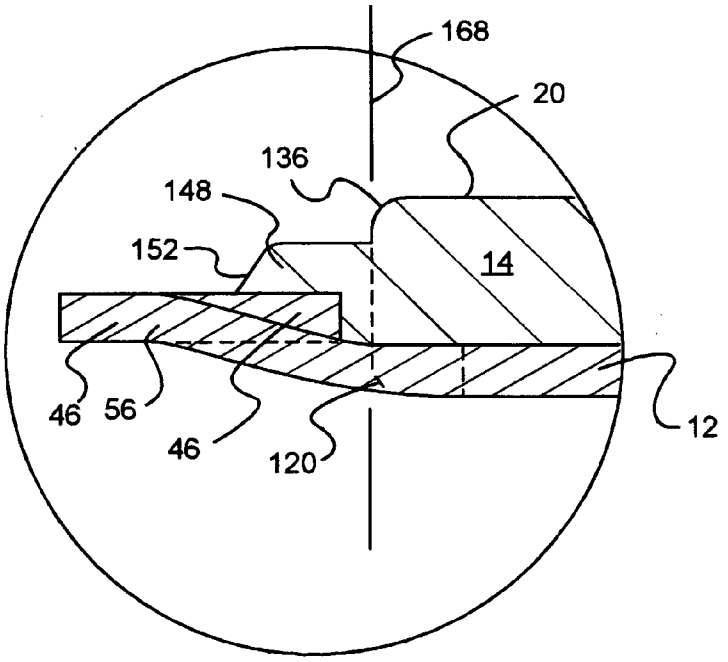


FIG. 24

# APPARATUS USED TO PACKAGE MULTIMEDIA CARD BY TRANSFER MOLDING

## CROSS-REFERENCE TO RELATED APPLICATION

This application is a divisional of application Ser. No. 09/878,302, filed Jun. 11, 2001, pending.

## BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates generally to semiconductor manufacture. More particularly, the invention pertains to an improved semiconductor card, and to improved methods and systems for fabricating the card.

[0003] 2. State of the Art

[0004] One type of electronic assembly containing semiconductor components is generally referred to as a "card". Examples of such "cards" include multi media cards such as used in digital cameras and the like, memory cards, smart cards, and personal computer memory card international association (PCMCIA) cards. The instant patent application refers to these types of cards as "semiconductor cards". These cards are sometimes referred to as "daughter boards".

[0005] Typically, a semiconductor card comprises a substrate which may be a thin printed circuit board (PCB) upon which electronic components are mounted. Such components may include, for example, at least one semiconductor die and/or die package as well as resistors, capacitors, inductors and the like to form a desired circuitry. The substrate includes conductors for providing power supply and interconnection of the various components. Typically, the components are mounted on one side, i.e. "circuit" side of the substrate, and are electrically interconnected to external contacts on the opposing side by interlevel conductors. The external contacts are arranged for electrical contact with a next level package, i.e. mother board. In use in an exemplary electronic apparatus such as a digital camera, the card may be inserted into a slot or other receiver for interconnection with a motherboard, and provide for example, flash memory for digitally recording images.

[0006] Semiconductor cards are typically intended for repeated handling by the public, necessitating protection of the components from mechanical forces, moisture, radiation and stray electrical currents. In the industry, the semiconductor components and interconnecting conductors on the circuit side of a card substrate have typically been encapsulated by first applying "glob top" encapsulant. Then, a separately formed protective cover produced by injection molding is adhesively attached over the circuit side of the substrate to form the semiconductor card. However, use of a separately formed cover not only adds undesirable thickness to the card, it requires additional process steps, and is subject to deleterious detachment of the cover from the substrate. In addition, any variation in mounted component height and overlying glob top material will result in card thickness variation.

[0007] For most applications, it is desirable to make the card as thin as possible. The use of thin cards saves space within the equipment in which the card is used, as well as storage space, and a saving in encapsulation material is also realized.

[0008] A further requirement for semiconductor cards is that the peripheral outlines and card dimensions be as uniform as possible, so that proper effective insertion into a card receiver is assured. Specifications on the peripheral outline and dimensions of semiconductor cards have been set by various industry standard setting bodies, e.g. PCMCIA.

[0009] In present methods of manufacture, components for several semiconductor cards are fabricated and wire bonded on a strip of e.g. circuit board. The strip may be viewed as equivalent to the lead frame in die manufacture. The individual cards are then separated from the strip using a singulation process such as sawing. Often the singulation step produces slivers, and forms substrate edges which are rough or sharp. These defects can adversely affect the peripheral outline, dimensions, appearance and use of the card.

[0010] The need exists for a method to encapsulate a semiconductor card whereby the card has reduced thickness as well as less variation thereof. In addition, the desired method will produce a card with improved precision in peripheral outline, dimensions and appearance, and at lower cost.

## BRIEF SUMMARY OF THE INVENTION

[0011] In accordance with the present invention, an improved semiconductor card is provided. In addition, a method and a system for fabricating the improved card are disclosed.

[0012] The semiconductor card includes a substrate such as a printed circuit board (PCB). The substrate comprises an electrically insulative material such as an organic polymer resin reinforced with glass fibers, and may include more than one layer. The substrate has a circuit side with a pattern of conductors thereon, and an opposing back side with a pattern of external contacts thereon. Electronic components such as semiconductor dice, resistors, capacitors, and the like are formed or mounted on the circuit side of the substrate. The semiconductor dice may comprise bare dice wire bonded to the conductors, bumped dice flip chip mounted to the conductors, or semiconductor packages bonded to the conductors. A single molding step serves to encapsulate the circuit side of the substrate and simultaneously form card surfaces and edges with smooth rounded or oblique corners.

[0013] A substrate may be initially formed as a segment of a substrate strip containing more than one module having a substrate separated therefrom by a peripheral opening. The strip is similar in function to a semiconductor lead frame, and permits various fabrication processes to be performed on one or more substrate at the same time. The substrate is connected to the strip with connecting segments similar to tie bars on a semiconductor lead frame.

[0014] A molding assembly is adapted to form a plastic body larger than the substrate, and simultaneously encapsulates circuit components such as dice, resistors, capacitors, bond wires,etc. on the substrate as the card body is formed. Plastic wings are also formed by molding, extending outwardly from a central portion of the card edges along major sides of the card periphery.

[0015] Prior to introducing molding compound, a plurality of down-set pins are inserted downward through the upper

plate, outside of the card periphery, to depress the connecting segments and attached substrate downward into a cavity. The resulting substrate will be lower than the frame portion of the module, and provide the back side of the semiconductor card.

[0016] Following molding, the casting is removed and desingulated by cutting off the wings.

[0017] The method is much simpler and quicker than the prior method in which the circuit side of a card is glob topped and then covered by a separately molded cap which is cemented thereto.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0018] **FIG. 1** is an enlarged isometric view of a semiconductor card of the invention;

[0019] **FIG. 2** is an enlarged plan view of a semiconductor card fabricated in accordance with the invention;

[0020] **FIG. 3** is an enlarged bottom view of a semiconductor card fabricated in accordance with the invention;

[0021] **FIG. 4** is an enlarged side cross-sectional view of a semiconductor card fabricated in accordance with the invention, as taken along line **4-4** of **FIG. 2**;

[0022] **FIG. 4A** is an enlarged side cross-sectional view of a portion of a semiconductor card in accordance with the invention, as taken from portion **4A** of **FIG. 4**;

[0023] **FIG. 4B** is an enlarged side cross-sectional view of a portion of a semiconductor card in accordance with the invention, as taken from portion **4B** of **FIG. 4**;

[0024] **FIG. 5** is an enlarged plan view of a semiconductor card on a strip in accordance with the invention;

[0025] **FIG. 6** is an enlarged isometric view of a molding apparatus for forming a semiconductor card in accordance with the invention;

[0026] **FIG. 7** is an enlarged plan view of a lower plate of a molding apparatus for forming a semiconductor card in accordance with the invention;

[0027] **FIG. 8** is a further enlarged plan view of a lower plate of a molding apparatus of the invention, as taken from portion **8** of **FIG. 7**;

[0028] **FIG. 9** is a cross-sectional side view of a portion of a lower plate of a molding apparatus of the invention, as taken along line **9-9** of **FIG. 8**;

[0029] **FIG. 10** is an enlarged plan view of the lower side of an upper plate of a molding apparatus for forming a semiconductor card in accordance with the invention;

[0030] **FIG. 11** is a further enlarged plan view of the lower side of an upper plate of a molding appartus of the invention, as taken from portion **11** of **FIG. 10**;

[0031] **FIG. 12** is a cross-sectional side view of a portion of an upper plate of the invention, as taken along line **12-12** of **FIG. 11**;

[0032] **FIG. 13** is a cross-sectional side view of a portion of an upper plate of the invention, with an inserted down-set pin, as taken along line **12-12** of **FIG. 1**;

[0033] **FIG. 14** is a further enlarged plan view of the lower side of an upper plate of a molding apparatus of the invention, as taken from portion **14** of **FIG. 10**;

[0034] **FIG. 15** is a cross-sectional side view of a portion of an upper plate of the invention, as taken along line **15-15** of **FIG. 14**;

[0035] **FIG. 16** is a further enlarged plan view of the lower side of an upper plate of a molding appartus of the invention, as taken from portion **16** of **FIG. 10**;

[0036] **FIG. 17** is a cross-sectional side view of a portion of an upper plate of the invention, as taken along line **17-17** of **FIG. 16**;

[0037] **FIG. 18** is an enlarged partial cross-sectional end view of a molding apparatus of the invention illustrating a configuration of the molding cavity for fabrication of a plastic body on a substrate;

[0038] **FIG. 19** is an enlarged partial cross-sectional end view of a molding apparatus of the invention illustrating a configuration of the molding cavity for fabrication of a plastic body on a substrate;

[0039] **FIG. 20** is an enlarged partial cross-sectional end view of a molding apparatus of the invention illustrating a configuration of the molding cavity for fabrication of a plastic body on a substrate;

[0040] **FIG. 21** is an enlarged plan view of a mold casting of the semiconductor card and attached frame of the invention, prior to singulation;

[0041] **FIG. 22** is an enlarged lower end view of a molded semiconductor card and attached frame of the invention, prior to singulation;

[0042] **FIG. 23** is an enlarged cross-sectional end view of a molded semiconductor card and attached frame of the invention, prior to singulation, as taken along section line **23-23** of **FIG. 21**;

[0043] **FIG. 24** is an enlargement of portion **24** of **FIG. 23**; and

[0044] **FIG. 25** is an enlarged cross-sectional side view of a molded semiconductor card and attached frame of the invention, prior to singulation, as taken along section line **25-25** of **FIG. 21**.

## DETAILED DESCRIPTION OF THE INVENTION

[0045] The invention is described and illustrated herein below in terms of a semiconductor card **10** which is exemplified by a "multimedia card". **FIGS. 1 through 4** illustrate an improved semiconductor card **10** constructed in accordance with the invention. The card **10** includes a substrate **12** (see **FIG. 4**) and at least one semiconductor element **16** (see **FIG. 4**) mounted to the substrate. The semiconductor card **10** also includes a plastic body **14** which is molded to portions of the substrate **12**, and an array of external contacts **18** (see **FIG. 3**) on the substrate **12** for electrical connection with another circuit. Thus, for example, a semiconductor card **10** containing memory (e.g. flash memory) may be configured for removable insertion into photographic devices for digital recording and retrievable storage of still pictures or video, and optionally audio.

[0046] As shown in **FIGS. 1-4**, card **10** has a length **24**, width **26** and thickness **28**. The thickness **28** may typically be set at a desirable value in the range of about 1 mm to about 6 mm. In an exemplary multi media card **10** described herein, the length, width, thickness and other aspects of the card may be set by an industry standards group, or alternatively the card configuration is decided by each manufacturer. In the particular example shown, the card **10** has a length **24** of about 32 mm., a width **26** of about 24 mm., and a typical thickness **28** of about 1-3 mm. As depicted in **FIGS. 1 and 2**, the exemplary card may include a slightly depressed label area **30** for attachment or inking of a label (not shown) on the front face **20**. The label area **30** is shown with an exemplary height **32** and width **34**.

[0047] The front face **20** and back face **22** of the semiconductor card **10** are joined by a peripheral edge **36** having rounded corners **38**. In accordance with the invention, the longitudinal edge **40** about the front face **20**, and the longitudinal edge **42** about the back face **22** are shown as rounded to a radius **21** of e.g. about 0.20 mm. for ease of use. See **FIG. 4A**. As depicted in **FIG. 4B**, the edges **40** and **42** may be alternatively "drafted" by molding an oblique face **23** on the edge.

[0048] As depicted in **FIGS. 1, 2**, and **4**, a groove **76** is formed in the front face **20**, acting as a finger grip for ease of handling.

[0049] In **FIG. 5**, a module **48** including substrate **12** is depicted as a thin sheet formed of an electrically insulating material such as an organic polymer resin reinforced with glass fibers. Suitable materials for the module **48** include bismaleimide-triazine (BT), epoxy resins (e.g. "FR_4" and "FR-5"), and polyimide resins. Any of these materials can be formed as a sheet of the desired thickness, and then punched, machined or otherwise formed with a required peripheral configuration and with other desired features. A representative thickness of the sheet of module **48** can be from about 0.2 mm to 1.6 mm. The substrate **12** and surrounding frame **46** together comprise the module **48** having a width **50** and length **52**. The module **48** may initially be a segment of a strip **44** which is used to fabricate several cards **10** at the same time. One or more substrates **12** may be formed from a strip **44**, each substrate being defined by a peripheral opening **54** with inner edge **176** and outer edge **174**. Non-substrate portions of the module **48** which surround the substrate **12** are herein denoted as a frame **46**. The width **84** of the peripheral opening **54** is configured so that the peripheral outline **70** (hatched line of **FIG. 5**) of the produced card **10** lies within the peripheral opening. The substrate **12** is connected to the frame **46** (and supported thereby) by a plurality of connecting segments **56**, which are similar to tie bars used in lead frames for semiconductor manufacture. The peripheral opening **54** is shown as extending into the frame **46** on both sides of each connecting segment **56**, in order to provide a desired segment length **58**. A width **68** of each connecting segment **56** is provided which supports the substrate **12** during processing. The module **48** containing substrate **12** includes indexing openings **78** for aligning the substrate **12** with a cutting tool, not shown, and a molding apparatus **80**, described infra. The module **48** may contain other openings **82** for other purposes.

[0050] As shown in **FIG. 5**, the peripheral opening **54** may be cut in module **48** to provide substrate **12** with a generally rectangular peripheral shape but with one chamfered corner **60**. As shown in **FIG. 1**, the resulting card **10** includes a chamfered corner **66**. The purpose of chamfered corner **66** is to generally identify the end of the card **10** having external contacts **18**, and ensure that a user inserts the card in a proper orientation. However, the invention applies to a card **10** or a substrate **12** of any shape. Also shown in **FIG. 1** are exposed ends **56**A of connecting segments **56** in the as-molded card **10** after molding of the plastic body **14** and singulation from the frame **46**. See also **FIG. 3**.

[0051] The substrate **12** includes a circuit side **62** (**FIG. 5**) and an opposing back side **64** (see **FIG. 3**) which in this embodiment comprises the card's backface **22**. In **FIG. 5**, a longitudinal center line **94** of strip **44**, and a longitudinal center line **96** of module **48** are shown for reference. A peripheral edge **72** joins the circuit side **62** and the back side **64** of the substrate **12**. As illustrated in the exemplary substrate **12** of **FIG. 5**, the circuit side **62** has mounted therein semiconductor components **16** as well as electrical components **74** such as resisters, capacitors, and inductors. A circuit is completed by connecting the semiconductor components **16**, electrical components **74** and external contacts **18** (see **FIG. 3**) with a pattern of conductors, e.g. wires, printed conductors, vias, and the like, not shown in the figures. Contacts (not shown) may also be provided to establish test circuits for example, typically on the circuit side **62** of the substrate. Methods and apparatus for forming, attaching and conductively interconnecting components **16**, **74** and **18** are well known in the art. The circuit on the substrate **12** may be configured to perform a desired function such as for example, memory storage, sound production, video production, games, product identification, etc.

[0052] The external contacts **18** are configured for mating electrical engagement with corresponding contacts (not shown) on a mother board circuit or other electrical assembly (not shown). As illustrated, the external contacts **18** may be planar pads formed of a non-oxidizing conductive material such as gold. However, other configurations for the external contacts **18** may be used, including bumps, pins, or pillars, for example, where the particular application permits.

[0053] In other processes for making semiconductor cards **10**, components **16** and **74** together with other apparatus on the circuit side **62** are encapsulated with a glob-top material which is cured prior to forming the outer card surfaces. No such encapsulation is utilized in the present invention. As described herein, a method of the invention provides for a single encapsulation step by precise molding which simultaneously encapsulates active components **16**, **74** on the circuit side **62** of the substrate **12** and forms smooth outer surfaces of the card **10** including rounded or drafted (angular) peripheral card edges **36**.

[0054] Regardless of the particular application to which the card circuit is directed, semiconductor card **10** of the invention includes a plastic body **14** which is molded directly to the circuit side **62** of substrate **12**, covering semiconductor component(s) **16**, electrical component(s) **74** and exposed conductors, bond pads, etc. which are mounted thereon. As shown in **FIG. 6**, the molding assembly **80** is of a type generally characterized as a transfer mold with mating first (e.g. lower) plate **84** and second (e.g. upper) plate **86** with an interface **88** intermediate the two plates. As known

in the art, such molding assembly **80** will include an internal mold cavity **100** having internal surfaces **160**A, **160**B in the lower plate **84** and upper plate **86**, respectively (see **FIGS. 7 and 10**), and alignment apertures **90** for precise joining of the plates. In addition, there are openings **92** for introduction of flowable polymeric molding compound (not shown) into the mold cavity **100**. In addition, the molding assembly **80** is modified in accordance with the invention to include a plurality of down-set pins **102** (see **FIGS. 10-13**, and **18**) which may be inserted downward along axes **104** in holes **106** passing through the upper plate **86**, as explained further below.

[**0055**] Furthermore, the molding assembly **80** is modified to form wings **148** of molded plastic material; the wings **148** extend laterally from areas between the rounded or drafted card edges **40**, **42** along portions of the card's peripheral edge **36**. Following extraction from the molding apparatus **64**, the wings **92** are excised by a smooth cut about the card's peripheral edge **36**, providing a card **10** with very little if any flash material, and with generally smooth edges **40** and **42**.

[**0056**] Turning now to **FIGS. 7 through 9**, which show the first (lower) plate **84** of a representative molding assembly **80** for forming a card **10** from a substrate **12**. The first plate **84** has an upper side **140** with an internal mold surface **160**A, and a lower side or base **138**. The first plate **84** includes a peripheral raised portion **108** to hold a module frame **46** at a first level **110**. The outer edge **122** of peripheral raised portion **108** may be dimensionally smaller than the module **48**. A depressed portion **112** laterally inside of the raised portion **108** is configured to accept a substrate **12** at lower level **114**, with space for forming a plastic periphery about the substrate. The substrate is connected to the frame **46** by connecting segments **56**. Portions **116** of the depressed portion **112** may be depressed further to accommodate external contacts **18** protruding from the backside **64** of the substrate **12**. Laterally intermediate the raised portion **108** and the depressed portion **112** is a lower edge portion **118** of the lower mold plate **84**. The lower edge portion **118** has an inner arcuate surface **120** for forming rounded corners **38** and rounded edges **40**, **42** on the card **10**. The lower edge portion **118** passes upward through the peripheral opening **54** of the module **48**, and in some locations, its upper surface **124** generally abuts the upper plate **86** to form a flash free seam on the peripheral edge **36** of the card **10**. As shown, a plurality of slits **126** are formed through the lower edge portion **118** and raised peripheral portion **126** for passage of connecting segments **56** of the module **48** therethrough. The numbers and locations of the slits **126** (and matching substrate segments **56**) provide for downwardly motivated support of the substrate **12** in the depressed portion **112**.

[**0057**] **FIGS. 10 through 17** illustrate an upper molding plate **86** configured to contact the circuit side **62** of the substrate **12**. The upper molding plate **86** has and upper side **142** and a lower side **144**. The plate **86** is inverted in the figures for viewing the internal mold cavity **100** with an internal mold surface **160**B in the lower side **144**. Shown are alignment apertures **90**, a raised peripheral portion **128** (with boundary **132**) for contacting the upper surface **47** of frame **46**, and injection ports **130** along plate edge **162**, through which pressurized fluid polymer **15** is introduced into the mold cavity (see **FIGS. 16 and 17**). References to portions of the second i.e. upper plate **86** as being "raised" or "depressed" refer to the plate as in the inverted position, i.e. with the lower side **142** facing up, and the upper side **140** facing downward. This is particularly evident in the sectional views in **FIGS. 12, 13, 15** and **17**.

[**0058**] The mold cavity **100** includes a central depressed region **134** defined by arcuate or drafted walls **136**. In addition, outward cavity extensions or "wing cavities"**150** are shown on four sides of the central depressed region **134**. Each wing cavity **150** has an outer sloped or rounded wall **152** for ease of mold release. Thus, the central depressed region **134** is at a level **154** below the level **158** of side **144**. A step **146** upward from region **134** attains an intermediate level **156** forming the base of each wing cavity **150**.

[**0059**] As shown in **FIG. 17**, each injection port **130** may communicate with a runner **130**A and a gate **130**B for introducing liquified polymer **15** into the mold cavity **100** at a controlled rate. The molding assembly **80** may also include vents, not shown, for discharging air from the runners **130**A and mold cavity **100**, as known in the art.

[**0060**] Another feature of the upper plate **86** comprises a plurality of down-set pin through-holes **106**, each located above a connecting segment **56**. See **FIGS. 10, 11, 12** and **13**. A down-set pin **102** may be inserted in each hole **106** to motivate the connecting segments **56** and attached substrate **12** downward into and against the depressed portion **110**. Entry of liquid polymer to the backside **22** of the substrate **12** is thus prevented.

[**0061**] The down-set holes **106** and pins **102** are positioned entirely within the wing cavities **150**, outside of the peripheral edge **36** of the card **10**. The pin **102** is shown as being generally cylindrical with an outer end **166** and an inner end **164** which may be of reduced size. In the figures, the inner end **164** is shown as having a hemispherical shape with chamfered edges, but any shape which effectively clamps a connecting segment **56** against the depressed portion **110** may be utilized. For example, the inner end **164** may be square, rectangular, quarter round, lunate, etc. The holes **106** and down-set pins **102** are preferably configured so that the inserted pins **102** are always in the same position relative to the substrate **12**. As shown herein, the configuration of the molding apparatus **80** and the configuration of module **48** must be compatible.

[**0062**] **FIGS. 18, 19** and **20** show portions of a molding apparatus **80** assembled for forming an encapsulating polymeric body **14** on a substrate **12** of a module **48**. The dimensions of various parts are not necessarily to scale.

[**0063**] In **FIG. 18**, a module **48** is shown inserted between the upper side **140** of a first or lower plate **84** and the lower side **144** of a second or upper plate **86**. The module section is shown with a frame **46**, a substrate **12**, and one of the four connecting segments **56** linking the substrate to the frame. The connecting segment **56** has an inner end **170** and an outer end **172**. The connecting segment **56** is shown pushed downward by the inner end **164** of one of the down-set pins **102** into the depressed portion **112** of the lower plate **84**. The displacement **155** of the substrate **12** from the frame **46** may be small, i.e. about ⅕ of the substrate thickness **13**, or may be up to about 3 times the substrate thickness, depending on the thicknesses of substrate and card **10**.

[**0064**] The substrate **12** is shown with a circuit side **62** on which are mounted exemplary semiconductor components **16** with connecting bond wires **17**. The substrate **12** is held

downward to portion **112** by the connecting segments **56**, generally preventing passage of polymeric mold compound **15** onto the substrate's backside **64**. For reference purposes, the peripheral opening **54** over the majority of the substrate **12** generally has a width **55** extending from the inner end **170** to the opening's outer edge **174** (see also **FIGS. 19 and 20**).

[**0065**] In **FIG. 18**, the region **134** forming the front face of the molded card **10** is shown with a slightly indented area **30** in which a label may be applied. In addition, **FIG. 18** depicts a final singulation plane **168** relative to the molding assembly **80**. The semiconductor card **10** will be singulated from the frame **46** and wings **148** following removal from the molding assembly **80**.

[**0066**] Following molding and solidification of the casting in the molding assembly **80**, the unsingulated card **10** may be ejected from the mold by further insertion of down-set pins **102**, or use of other pins, not shown. Ease of ejection is enabled by the use of sloped lateral surfaces and rounded or oblique corners on the molded casting **180**.

[**0067**] **FIG. 19** depicts the molding assembly **80** with the module frame **46** and substrate **12** at a position away from a connecting segment **56**. Shown are wing cavities **150** in which wings **148** are formed. The lower edge portion **118** which surrounds the mold cavity **100** in the lower plate **84** fits within the peripheral opening **54** between edges **174** and **176**. The lower edge portion **118** molds an arcuate or oblique corner surface **120** on the molded card **10**.

[**0068**] **FIG. 20** depicts the molding assembly **80**, substrate **12** and module frame **46** in a portion where there is a substantial absence of wing cavities **150**, and the substrate has external contacts **18** on its back side **64**. As shown, a cavity **178** is formed in the lower plate **84** into which the contacts **18** fit. The external contacts, or even the entire back side **64** may in addition be covered by tape or other protective member (not shown) to ensure freedom from flash material on the card's back side.

[**0069**] In **FIG. 21**, a casting **180** molded on a semiconductor card module **48** is shown in front view following removal from the molding assembly **80**. The card module **48** includes a molded card body **14** with molded wings **148** extending outwardly therefrom along major peripheral edges **36**. The card body **14** has a width **26** and length **24**. The peripheral openings **54** are now filled with hardened molding material **15**, including on both sides of each connecting segment **56**. The card body **14** is connected to the module **48** along a central portion of its peripheral edges **36**, and its upper and lower peripheral edges **40**, **42** are smooth, rounded or oblique, and substantially free of "flash" material. This is evident by examination of **FIGS. 22, 23, 24** and **25**. The card **10** has a back side **22** comprising the back side **64** of the substrate **12**. The semiconductor card **10** is singulated from the module **48** by cutting it free along its peripheral edges **36**, i.e. through the wings **148**, by saw, erosion process or other cutting tool. The four small ends **56**A of the connecting segments **56** (see **FIG. 1**) which project from card edges **56** may be easily trimmed (if desired) by clipping or other methods. Alternatively, the ends **56**A may be pre-scored, i.e. prior to molding, to minimize protrusion of the ends **56**A from the card edges **56**.

[**0070**] In the manufacture of the semiconductor card **10** of the invention, the steps involved may be summarized as including:

[**0071**] a. A strip **44** of a dielectric material is provided in sheet form;

[**0072**] b. A peripheral opening **54** is formed in at least one portion of the strip **44** designated as a module **48**, in which the opening **54** defines the boundaries of a substrate **12**. Opposing sides of the substrate **12** is connected to a frame portion **46** of the module **48** by connecting segments **56** of the module **48**. Other openings **82** for indexing and handling are also provided.

[**0073**] c. A circuit **73** is formed on the "circuit" side **62** of the substrate **12**, including at least one semiconductor component **16** as well as electrical component(s) **74** and interconnecting conductors.

[**0074**] d. External contacts **18** are formed on the back side **64** of the substrate **12** and connected to circuit **73**.

[**0075**] e. A set of mold plates **84**, **86** is configured for molding a polymeric body peripherally **14** about the circuitized substrate **12** and over portions of the circuit side **62** thereof. Down-set pin holes **106** are provided outside of the card outline **70** in an upper mold plate **86** for insertion of pins **102** to motivate the connecting segments **56** (and attached substrate **12**) downward to a lower level against a lower surface of the internal molding cavity **100** in the lower mold plate **84**.

[**0076**] f. The lower mold plate **84** and upper mold plate **86** are assembled with module **48** therebetween. The molding assembly **80** is connected to a supply of molding compound and clamped shut. Down-set pins **102** are positioned in the holes **106** to force the substrate **12** downward to a seated position.

[**0077**] g. Fluid polymeric molding compound **15** is introduced into the molding assembly **80** under conditions which rapidly fill the mold cavity **100**, encapsulating the circuit **73** and forming a plastic body **14**.

[**0078**] h. After curing and cooling of the mold material **15**, the mold is opened and the molded module **48** removed therefrom. Pins may be inserted in throughholes **106** and used as ejection tools for releasing the module.

[**0079**] i. The card **10** is singulated from its module **48** by cutting along the card outline **70**.

[**0080**] j. If desired, exposed ends **56**A of the connecting segments **56** within the card **10** may be cut back. If necessary, flash residue may be removed.

[**0081**] In another embodiment of the invention, the molding assembly **80** may be configured to cover portions of both sides **20**, **22** of a substrate **12**. The molding cavity **100** of lower plate **84** is varied by providing one or more additional cavities and associated runners for introducing bonding compound **15**.

[**0082**] As described herein, the invention provides a semiconductor card by a method which eliminates a separate glob top encapsulation step, and ensures smooth card edges which are rounded or oblique. Desired card dimensions are readily maintained, and flash material requiring removal is

minimized. If desired, the molding assembly may be configured to form several cards simultaneously.

[0083] It is apparent to those skilled in the art that various changes and modifications may be made in the manufacturing methods and apparatus of the invention as disclosed herein without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A transfer mold assembly for forming a semiconductor card with peripheral card edges from a planar module having a peripheral opening defining a substrate therein, said opening interrupted by a plurality of narrow module segments, said assembly comprising:

a first plate having a first molding surface for contacting the back side of a planar module;

a second plate having a second molding surface for contacting the circuit side of the planar module;

an internal molding cavity comprising portions of the first and second molding surfaces;

Apparatus for injecting fluid molding compound into the internal molding cavity;

peripheral molding structures defining lateral edges of a semiconductor card body, said molding structures having a plurality of slits for downward passage of said module segments;

a plurality of internal molding cavity portions comprising wing cavities projecting outwardly from the peripheral molding structures; and

a plurality of throughholes in the second plate, said throughholes aligned with the module segments outside of the peripheral molding structures.

2. A transfer mold assembly in accordance with claim 1, further comprising:

a plurality of down-set pins insertable in said throughholes to motivate module segments and substrate attached thereto downwardly from the frame to a lower position against a cavity surface, said throughholes positioned to pass through said wing cavities outside of said peripheral molding structures.

3. A system for forming a semiconductor card having a card periphery, comprising:

a planar module having a substrate formed therein by a peripheral opening surrounded by a frame;

a plurality of segments of the module connecting said substrate to said frame;

a transfer mold assembly comprising:

a first plate having a first molding surface for contacting the back side of a planar module, said first plate having a peripheral raised portion with a plurality of slits for passage of module segments therethrough;

a second plate having a second molding surface for contacting the circuit side of the planar module;

an internal molding cavity comprising portions of the first and second molding surfaces;

means for injecting fluid molding compound into the internal molding cavity;

peripheral molding structures defining lateral edges of a semiconductor card body;

a plurality of internal molding cavity portions comprising wing cavities projecting outwardly from the peripheral molding structures;

a plurality of throughholes in the second plate, said throughholes aligned with the module segments outside of the peripheral molding structures; and

a plurality of down-set pins insertable in said throughholes to motivate module segments and substrate attached thereto downwardly from the frame to a lower position against a cavity surface, said throughholes passing through said wing cavities outside of said peripheral molding structures.

4. A system in accordance with claim 3, wherein said module comprises one of a set of modules on a strip insertable into a molding assembly for simultaneous molding.

5. A system in accordance with claim 3, wherein said molding assembly comprises a transfer mold.

6. A system in accordance with claim 3, wherein said plurality of connecting module segments comprises four segments.

7. A system in accordance with claim 3, wherein the peripheral opening has a width which is increase adjacent the outer ends of said module segments.

8. A system in accordance with claim 3, further comprising ejection pins insertable into said throughholes to eject said casting from said molding assembly.

9. A mold assembly for forming a semiconductor card having peripheral card edges from a planar module having a peripheral opening defining a substrate therein, said opening interrupted by a plurality of narrow module segments, said mold assembly comprising:

a first plate having a first molding surface for contacting the back side of a planar module;

a second plate having a second molding surface for contacting the circuit side of the planar module;

an internal molding cavity including portions of the first and second molding surfaces;

apparatus for injecting fluid molding compound into the internal molding cavity;

peripheral molding structures defining lateral edges of a semiconductor card body, said molding structures having a plurality of slits for downward passage of said module segments;

a plurality of internal molding cavity portions comprising wing cavities projecting outwardly from the peripheral molding structures; and

a plurality of throughholes in the second plate, said throughholes aligned with the module segments outside of the peripheral molding structures.

10. A mold assembly in accordance with claim 9, further comprising:

a plurality of down-set pins insertable in said throughholes to motivate module segments and substrate attached thereto downwardly from the frame to a lower position against a cavity surface, said throughholes

positioned to pass through said wing cavities outside of said peripheral molding structures.

**11**. A system for making a semiconductor card having a card periphery, comprising:

a planar module having a substrate formed therein by a peripheral opening surrounded by a frame;

a plurality of segments of the module connecting said substrate to said frame;

a transfer mold assembly comprising:

a first plate having a first molding surface for contacting the back side of a planar module, said first plate having a peripheral raised portion with a plurality of slits for passage of module segments therethrough;

a second plate having a second molding surface for contacting the circuit side of the planar module;

an internal molding cavity comprising portions of the first and second molding surfaces;

means for injecting fluid molding compound into the internal molding cavity;

peripheral molding structures defining lateral edges of a semiconductor card body;

a plurality of internal molding cavity portions comprising wing cavities projecting outwardly from the peripheral molding structures;

a plurality of throughholes in the second plate, said throughholes aligned with the module segments outside of the peripheral molding structures; and

a plurality of down-set pins insertable in said throughholes to motivate module segments and substrate attached thereto downwardly from the frame to a lower position against a cavity surface, said throughholes passing through said wing cavities outside of said peripheral molding structures.

**12**. A system in accordance with claim 11, wherein said module comprises one of a set of modules on a strip insertable into a molding assembly for simultaneous molding.

**13**. A system in accordance with claim 11, wherein said molding assembly comprises a transfer mold.

**14**. A system in accordance with claim 11, wherein said plurality of connecting module segments comprises four segments.

**15**. A system in accordance with claim 11, wherein the peripheral opening has a width which is increase adjacent the outer ends of said module segments.

**16**. A system in accordance with claim 11, further comprising ejection pins insertable into said throughholes for ejecting said casting from said molding assembly.

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